U.S. Department
of Transportation

**Federal Aviation
Administration**

Great Lakes Region
Illinois, Indiana, Michigan,
Minnesota, North Dakota,
Ohio, South Dakota,
Wisconsin

2300 E Devon Avenue
Des Plaines, Illinois 60018

POLICY AND PROCEDURES MEMORANDUM - AIRPORTS DIVISION

NUMBER:		5210.1A
DATE:		APR 1 2 1993
SUBJECT:		Great Lakes Region Interim Eligibility Criteria for a High Mobility Aircraft Rescue and Fire Fighting (ARFF) Vehicle.
CANCELLATION:		PPM 5210.1 dated April 9, 1985
APPENDICES:	1	Procedure for Determining a VCI, to Specify for a High Flotation Type ARFF Vehicle.
	2	Determining the Rating Cone Index (Measuring Trafficability).
	3	Terminology and Concepts.
	4	Instruments and Tests for Trafficability.
	5	Additional Information.
	6	Changes from PPM 5210.1
	7	Resolution of Comments. (Internal Use Only)

1. Background: Various airport sponsors in the Great Lakes Region have expressed an interest in obtaining, with Federal participation, a high mobility type Aircraft Rescue and Fire Fighting (ARFF) vehicle to be able to reach off-pavement areas of the airport that would be inaccessible to a standard ARFF vehicle. The Great Lakes Region has developed the following Policy/Procedure, which is intended to remain in effect until national criteria is developed.

Distribution: AGL-600/601/602/603/605/ 610/620; ADO-CHI/ADO-DET/ ADO-MSP/ADO-BIS State Aviation Directors (for information thru ADO's)

Originator: AGL-620

2. Policy/Procedure: If an airport has large inaccessible, underdeveloped areas, such as swamps, plowed fields (with or without crops), or seasonal wetlands, the sponsor may specify an ARFF vehicle with a vehicle cone index (VCI) low enough to traverse the inaccessible area (on a one time basis). The sponsor must indicate the maximum ground slope and type of ground cover of the inaccessible area(s) in the bid specifications to permit potential bidders to properly rate their piece of equipment against the specification requirement.

a. The decision to purchase a high mobility type ARFF vehicle rather than a conventional ARFF vehicle will be the airport sponsor's.

b. The attached appendices outline a procedure an airport sponsor can use in determining what vehicle cone index (VCI_1) to specify. If another procedure is used, it must first be approved by the Great Lakes Region. The cost of conducting reasonable soil trafficability tests will be an eligible reimbursable project expense of obtaining the ARFF vehicle.

c. The above criteria may not necessarily apply to airports with extremely high snowfall (in excess of 50" of seasonal snow). The ARFF needs of these airports should be studied on an individual basis.

d. All ARFF vehicles proposed for acquisition with Federal participation shall meet the requirements of FAR Part 139 and shall be eligible as required.

W. Robert Billingsley
Manager, Airports Division

Appendix 1

Procedure for Determining a VCI, to Specify for a High Flotation Type ARFF Vehicle

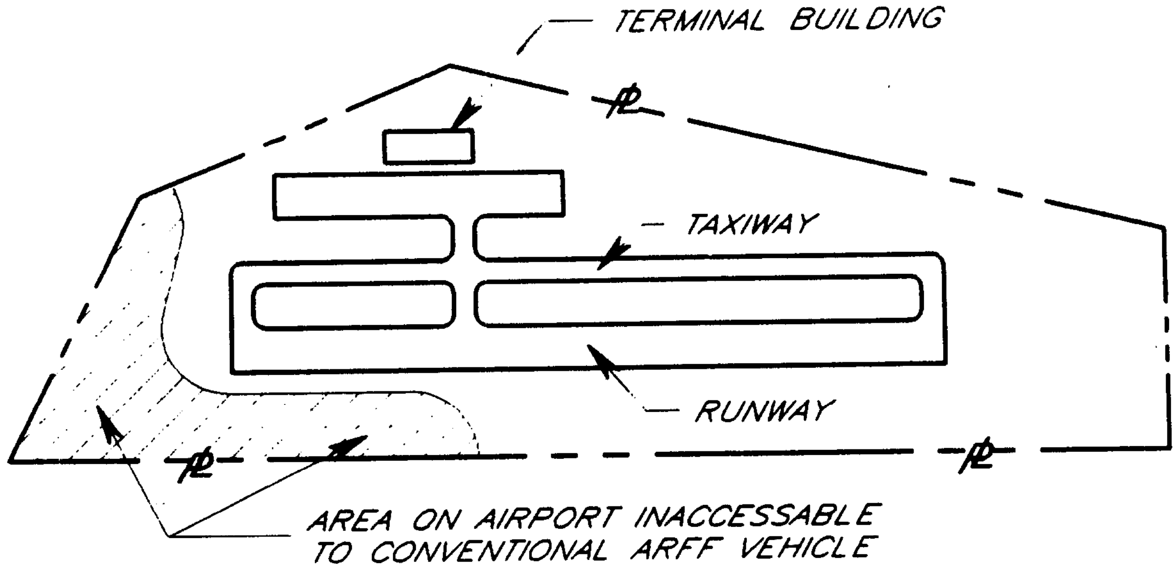

DIAGRAM - AIRPORT "A"

1. Cone penetrometer tests are taken in areas which, as determined by past experience or by actual field testing, are inaccessible to conventional ARFF equipment. An average cone index is determined from the cone penetrometer tests.

2. A series of remolding tests are then performed on the inaccessible area and an average remolding index determined.

3. The rating cone index of the inaccessible area is determined by multiplying the cone index by the remolding index.

4. The vehicle cone index (VCI) of the ARFF vehicle for one pass through the inaccessible area should be equal to or less than the rating cone index of the inaccessible area.

5. Appendix 2 explains the procedure for determining the rating cone index of an area. Appendix 3 explains terms and concepts. Appendix 4 describes test instruments and the actual test for trafficability.

Appendix 2

Determining the Rating Cone Index (Measuring Trafficability)

Data can be obtained to permit determination of the number and type of vehicles that can cross the area and the slopes they can climb. The procedures for measuring trafficability are described in this appendix. It should be remembered that measurements are valid only for the time of measurement and short periods thereafter, provided no rain occurs.

Range of Cone Indexes

The range in cone indexes in the critical layer that is of maximum interest is between about 10 and 300. Only the most mobile of vehicles and some special-purpose experimental vehicles can travel one pass on soils whose cone index is as low as 10. A 180-pound man can walk with relative ease on soil whose cone index is 12. These limits usually make it possible, in gathering data for trafficability evaluation, to classify large areas without extensive testing.

Number of Measurements

The number of measurements to be taken is determined by available time tempered by judgment as to the range of soil strengths and the general uniformity of the area. The trafficability measuring instruments have been designed to facilitate rapid observations. The accuracy of the average of any series of readings increases with the number taken. It has been found, for example, that the variations in a typical soft soil are such that about 15 readings are needed to establish a true average cone index at any particular spot at a given depth, and that if 15 readings are made within a radius of 3 feet in a uniform-appearing area, the addition of another reading will not significantly change the average.

Only a few readings are needed in an area with cone indexes above or below the critical range of 10 to 300. However, if cone indexes are within this critical range or, more particularly, between about 10 and 150, many readings should be taken to assure complete and accurate coverage of the area. Readings should be made at enough locations to establish the boundaries of the area and the average cone index within fairly close limits. At least three sets of readings should be made at each location. Remolding tests (in the case of fine-grained soil and remoldable sand) should also be run at a sufficient number of locations to establish the range of remolding indexes.

Where cone index ranges from 150 to 200, sufficient locations should be selected to verify the limits of the area as established by visual inspection. Three or four sets of readings should be made at each location. For fine-grained soils and remoldable sands, remolding tests should be made at the first two or three locations; if these show a remolding index of 0.90 or more, no additional remolding tests need be made. If the remolding index is below 0.90, and especially if it is much below, a sufficient number of remolding tests should be made to establish the range for the area. Generally, this can be established with tests at about six locations.

Where cone indexes are about 200, a very few penetrometer readings normally will suffice to verify the extent of the area. Two sets of profile readings at each of a few locations should be adequate, and remolding tests on soil from the critical layer (fine-grained soils and remoldable sands) should be made at the first two or three locations. If these show a remolding index of 0.80 or more, no additional remolding tests need be made. Sufficient tests should be made to establish the range for the area if the remolding index is below 0.80, and especially if it is much below. Generally, this can be established with tests at about four locations.

Where cone indexes are below 10, readings should be limited to the number needed to establish the limits of the nontrafficable area. No remolding tests are required.

Remolding Test

Since remolding test techniques for fine-grained soils differ somewhat from those for remoldable sands, the operator should be able to recognize the two types of soil for conditions where remolding tests must be made. In such conditions, both soil types are wet in appearance and wet to the touch. If squeezed and rolled between the fingertips, the fine-grained plastic soil will feel soft and smooth because such soil particles are small and flat in shape. The other soil type will have a definite abrasive feel because of the presence of the larger, rounder particles of sand. However, there will be many cases in which the operator cannot confidently distinguish the two types. In such cases, both types of remolding tests should be made and the remolding indexes obtained compared. If the lower remolding index is the one obtained with the remolding test for remoldable sands, it may be assumed that the soil is a remoldable sand; and the test for this soil type should be employed throughout the area under investigation. It is emphasized that a good rule to follow in cases of doubt is to run both types of tests and use the lower remolding index.

Rating Cone Index

The rating cone index is the cone index that will result under traffic and is the final cone index evaluation of a given area. Assuming that the cone index for an area is 85 and the remolding index is 0.80, the rating cone index then would be 85 x 0.80 = 68.

Critical Layer

The depth of the critical layer varies with soil type, the soil's strength profile, the vehicle type and weight, and number of passes required.

Variations with Soil Type, Vehicle Weight and Type

Variations with soil type, vehicle weight and type, are as follows:

Type of Vehicle	Depth of Normal Critical Layer in One Pass	
	F-G Soils*	C-G Soils**
Sleds	0 to 3	0 to 3
Wheeled, up to 50,000 lbs.	0 to 6	0 to 6
Wheeled, over 50,000 lbs.	3 to 9	0 to 6
Tracked, up to 100,000 lbs.	0 to 6	0 to 6
Tracked, over 100,000 lbs.	3 to 9	0 to 6

* Fine-grained soils and remoldable sands
** Course-grained soils

Normal Strength Profile in Fine-Grained Soil and Remoldable Sand

In a soil with a normal strength profile, the cone index readings either increase or remain constant with each increment of depth. An example of an area with a normal strength profile is given in Table 1. Cone indexes should be measured at 6-inch increments down to 18 inches in the early stages of testing. If these measurements consistently reveal that the profile is normal, only readings are recorded for the 6- and 12-inch depths. In a normal profile, remolding tests should be run only on samples taken from the normal critical depth for the vehicle in question, since a decrease in remolding index with increasing depth is not common. The rating cone index for this layer is used as the criterion of trafficability for this particular vehicle.

Abnormal Strength Profile in Fine-Grained Soil and Remoldable Sand

In an abnormal strength profile, at least one cone index reading is lower than the reading immediately preceding it. An example of an area with an abnormal strength profile is given in Table 1. When it has been established that an abnormal strength profile exists, cone index readings should be made and recorded at 6-inch increments from the top of the normal critical layer to 6 inches below the bottom of the normal critical layer. Remolding tests must be run on samples taken from the normal critical layer and also from the 6-inch layer below. The lower rating cone index is used as the measure of trafficability. Sleds are an exception to this rule. The 0- to 3-inch layer is always used as the critical layer for these vehicles.

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Strength Profile in Course-grained Soil

The external layer for most vehicles in coarse-grained soils is the 0- to 6-in. layer. The vast majority of coarse-grained soils have a normal strength profile with a rather large increase in strength with depth when compared to fine-grained soils. For this reason, cone index measurements should be made at 3-inch increments to 18 inches, or until the maximum capacity (300 cone index) of the penetrometer has been reached. Usually fewer penetrations are required to establish an average since coarse-grained soil areas usually are more uniform than fine-grained soils and remoldable sands. No remolding index tests are required. An example of strength measurements in a coarse-grained soil area is given in Table 1.

Table 1. Examples of Normal and Abnormal Soil Strength Profiles
Fine-grained Soils and Remoldable Sands

Depth In.	Cone Index Penetration Test No.															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	AV
	Area A (Normal Stength Profiles)															
Surface	28	33	32	27	39	31	30	27	29	30	28	31	33	30	32	30
6	47	48	50	51	49	52	53	49	47	48	50	50	53	51	52	50
12	69	67	71	70	69	67	72	73	68	70	71	68	70	73	72	70
18	80	82	83	83	81	70	80	79	77	78	81	79	77	82	83	80

The results from three remolding tests made in the 6- to 12-in. layers are: 0.86, 0.91, and 0.93. The average remolding index for the layer is 0.90.

Depth In.	Area B (Abnormal Strength Profiles)															
Surface	32	30	33	31	28	30	29	27	30	31	29	27	32	33	28	30
6	77	78	75	73	76	75	73	78	77	72	74	75	76	72	74	75
12	42	42	45	46	44	47	48	44	42	43	45	46	47	47	46	45
18	38	37	34	36	35	33	32	36	37	37	36	35	33	32	34	35

The results from three remolding tests made in the 6- to 12-in. layer are: 0.87, 0.90, and 0.93. The average remolding index for the 6- to 12-in. layer is 0.90. The results from three remolding tests made in the 12- to 18-in. layer are: 0.88, 0.91, and 0.91. The average remolding index for the 12- to 18-in. layer is 0.90.

Depth In.	Cone Index Penetration Test No.										
	1	2	3	4	5	6	7	8	9	10	AV
	Course-grained Soils										
Surface	15	20	30	40	15	20	25	30	20	20	24
3	80	60	80	70	50	75	70	60	65	75	68
6	120	110	130	110	120	115	125	115	120	125	120
9	180	175	190	175	180	185	190	180	175	180	181
12	200	220	195	205	210	205	200	210	215	220	208
15	250	230	245	230	250	245	240	235	250	240	242
18	300+	250	280	295	300+	275	280	300+	290	290	284

Interpolating Values

Intermediate values for the 3-, 9-, and 15-inch depths (fine-grained soil and remoldable sands) can be interpolated whenever the vehicle types under consideration require them.

Examples. It is desired to investigate the following fine-grained soil areas for trafficability for vehicles that are of such type and weight that the 6- to 12-inch depth is the normal critical layer. Since Area A in Table 1 has a normal profile, a remolding test was run only for the 6- to 12-inch layer. The rating cone index for Area A is 60 (average of 50 and 70) x 0.90 = 54. In Area B, remolding tests were necessary for both the 6- to 12-inch and 12- to 18-inch layers. In this area, the rating cone index of the 6- to 12-inch layer is 60 (average of 75 and 45) x 0.90 = 54, and of the 12- to 18-inch layer is 40 x 0.90 = 36. The rating cone index of the 12- to 18-inch layer, 36, is the governing value for trafficability in Area B.

Other Factors

In addition to the cone index of an area, other factors should be considered in evaluating trafficability, as discussed in the following subparagraphs.

a. Slope. The steepest slope, or ruling grade, that must be negotiated should be measured or may be determined from the study of a contour map. The slope must be specified so all potential equipment bidders can properly rate their vehicles for bidding purposes.

b. Stickiness. No instrument for measuring the effects of stickiness on the performance of vehicles has yet been devised. Stickiness will occur in all fine-grained soils when they are comparatively wet. The greater the plasticity of the soil, the more severe are the effects of stickiness. In general, stickiness will have adverse effects on the speed and facility of travel and steering of all vehicles but will not in itself cause the immobilization of any vehicle, except the smallest of tracked vehicles. Even the worst conditions of stickiness are nothing more than a nuisance to the larger, more powerful vehicles. Removal of fenders will reduce stickiness effects on some vehicles.

c. Slipperiness. Like stickiness, the effects of slipperiness cannot be measured quantitatively. Soils that are covered with water or a layer of soft plastic soil usually are slippery and often cause steering difficulty, especially to rubber-tired vehicles. Immobilization can occur in many instances. Immobilizations occur frequently when slipperiness is associated with low bearing capacity. Slipperiness effects assume greater significance on slopes, and sometimes slopes whose soil strength is adequate may not be passable because of slipperiness. The use of chains on rubber-tired vehicles usually will be of benefit in slippery conditions.

d. Vegetation. The particular effects of vegetation on trafficability are not within the scope of this guidance, but some points are worthy of mention. Dense grass, especially if wet with dew or rain, may provide slippery conditions. Soil strength requirements will be greater than normal if small trees or thick brush must be pushed down by the vehicle.

e. Other Obstacles. A complete assessment of the trafficability of a given area must include an evaluation of obstacles such as forests, rivers, boulder fields, ditches, hedgerows, etc.

Appendix 3

Terminology and Concepts

Terminology

Certain terms peculiar to soils trafficability are defined as follows:

a. Bearing Capacity. The ability of a soil to support a vehicle without undue sinkage of the vehicle.

b. Traction Capacity. The ability of a soil to resist the vehicle-tread thrust required for steering and propulsion.

c. Cone Index. An index of the shearing resistance of soil obtained with the cone penetrometer; a number representing resistance to penetration into the soil of a 30-degree cone with 1/2-square-inch base area (actually load in pounds on cone base area in square inches).

d. Remolding. The changing or working of a soil by traffic, or by a remolding test. Remolding may have a beneficial, neutral, or detrimental effect, resulting in a change of soil strength.

e. Remolding Index. The ratio of remolded soil strength to original strength, determined in accordance with procedures to be described in paragraph 9-11. Soil conditions that permit the remolding test to be run usually are such that a loss of strength rather than an increase of strength results.

f. Rating Cone Index. The measured cone index multiplied by the remolding index; it expresses the soil-strength rating of a point subjected to sustained traffic.

g. Critical Layer. The soil layer in which the rating cone index (fine-grained soil) or cone index (course-grained soil) is considered the most significant measure of trafficability. Its depth varies with weight and type of vehicle, as well as with the soil profile. Generally, the critical layer for different soil types is defined as follows:

(1) Fine-grained soils: surface to 6-inch depth when subjected to one pass of a vehicle.

(2) Course-grained soils: surface to 6-inch depth for all vehicular passes.

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h. Vehicle Cone Index (VCI). The index asigned to a given vehicle that indicates the minimum soil strength in terms of rating cone index (or cone index for course-grained soil) required for one pass (VCI_1).

i. Stickiness. The ability of a soil to adhere to vehicles.

j. Slipperiness. Low traction capacity of a soil's surface owing to its lubrication by water or mud without the occurrence of significant vehicle sinkage.

k. Fine-grained Soil. A soil of which more than 50 percent by weight of the grains will pass a No. 200 sieve (smaller than 0.074 mm in diameter).

l. Course-grained Soil. A soil of which more than 50 percent by weight of the grains will be retained on a No. 200 sieve (0.074 mm and larger in diameter). For trafficability purposes, these are beach and desert soils usually containing less than 7 percent of material passing the No. 200 sieve, or soils containing 7 percent or more of material passing the No. 200 sieve but not in a wet condition (remoldable; see below).

m. Remoldable Sands. A course-grained soil, usually containing 7 percent or more of material pasing a No. 200 sieve, in which the water content greatly influences the trafficability characteristics and on which the remolding test can be performed. When wet, these soils react to traffic in a manner similar to fine-grained soils, except that they are more sensitive to remolding.

Basic Trafficability Concepts

a. Soil Strength. Both the bearing and traction capacities of soils are functions of their shearing resistance. Shearing resistance is measured by the cone penetrometer and is expressed in terms of cone index. Since the strength of a fine-grained soil may increase or decrease when loaded or disturbed, remolding tests are necessary to measure the gain or loss of soil strength to be expected under traffic. A comparison of the rating cone index with the vehicle cone index indicates whether the vehicle can neogitate the given soil condition. For example, if a soil has a cone index of 120 and a remolding index of 0.60 in its critical layer, its strength may be expected to fall to 120 times 0.60, or a rating cone index of 72, under traffic. Accordingly, it is considered that such a soil is not trafficable for vehicles with vehicle cone indexes greater than 72.

b. Stickiness. The operation of vehicles in wet fine-grained soil sometimes can be hampered seriously by stickiness. Under extreme conditions, sticky soil can accumulate in the running gear of a vehicle to the point where travel and steering are difficult. Normally, stickiness is troublesome only when it occurs in soils of low bearing capacity (normally fine-grained soils).

c. Slipperiness. The presence of excess water or a layer of soft plastic soil overlying a firm layer of soil can produce a slippery surface. Such a condition may make the steering of all vehicles difficult or immobilize rubber-tired vehicles. Vegetation, especially when wet and on a slope, may cause immobilization of rubber-tired vehicles. Slipperiness can be troublesome even when associated with soils of high bearing capacity.

d. Variation of Trafficability with Weather. Weather changes will produce changes in the trafficability of a soil. In rainy periods, fine-grained soils undergo an increase in moisture, with resultant increased slipperiness and stickiness and decreased strength. Dry periods have opposite effects. Loose sands improve in trafficability through an increase in cohesion as a result of rainy periods and return to the loose, less trafficable state during dry periods. It is apparent that trafficability characteristics measured on a given date cannot be applied later unless full allowance is made for the changes in soil strength caused by weather. Techniques have been developed for predicting the effects of weather on soil trafficability. These techniques are part of the comprehensive Army mobility prediction system and are not included in this appendix.

Appendix 4

Instruments and Tests for Trafficability

Test Set, Soil (Trafficability)

Trafficability measurements are made with the aid of the soil test set (trafficability). This set consists of the following items: one canvas carrying case, one cone penetrometer with 5/8-inch aluminum staff and 0.5-square-inch cone, one soil sampler, remolding equipment (includes 3/8-inch steel staff and 0.2-square-inch cone, 5/8-inch steel staff with foot, handle, 2-1/2-pound hammer, cylinder and base with pin), a bag of hand tools (two open-end wrenches 1/2" x 9/16", one 6-inch Stillson wrench, one combination spanner wrench and 1/4-inch screwdriver, one 3/16-inch Allen wrench and one 2-inch screwdriver with 1/8-inch bit). The items are shown in their proper places in the carrying case in Figure 1. The weight of the complete set is 19 pounds.

The Cone Penetrometer

The cone penetrometer is the principal instrument used in evaluating soils trafficability. It consists of a 30-degree cone of 1/2-square-inch base area, an aluminum staff 19 inches long and 5/8 inch in diameter, a proving ring, a micrometer dial, and a handle. When the cone is forced into the ground, the proving ring is deformed in proportion to the force applied. The amount of force required to move the cone slowly through a given place is indicated on the dial inside the ring. This force is considered to be an index of the shearing resistance of the soil and is called the cone index of the soil in that plane. The range of the dial is 0 to 300 (150 pounds). The proving ring and handle are used with a 3/8-inch-diameter, 19-inch-long steel staff for remolding tests in remoldable sands.

Use of the Penetrometer

a. Inspection. Inspect the penetrometer before using to make sure that all nuts, bolts, and joints are tight and that the dial-gage stem contacts the proving-ring bearing block.

b. Zeroing. Allow the penetrometer to hang vertically from its handle and rotate the dial face until "0" is under the needle. Note that when the instrument is kept vertical between the fingertips and allowed to rest on its cone, the dial will register about 4, or 2 pounds, the total weight of the instrument.

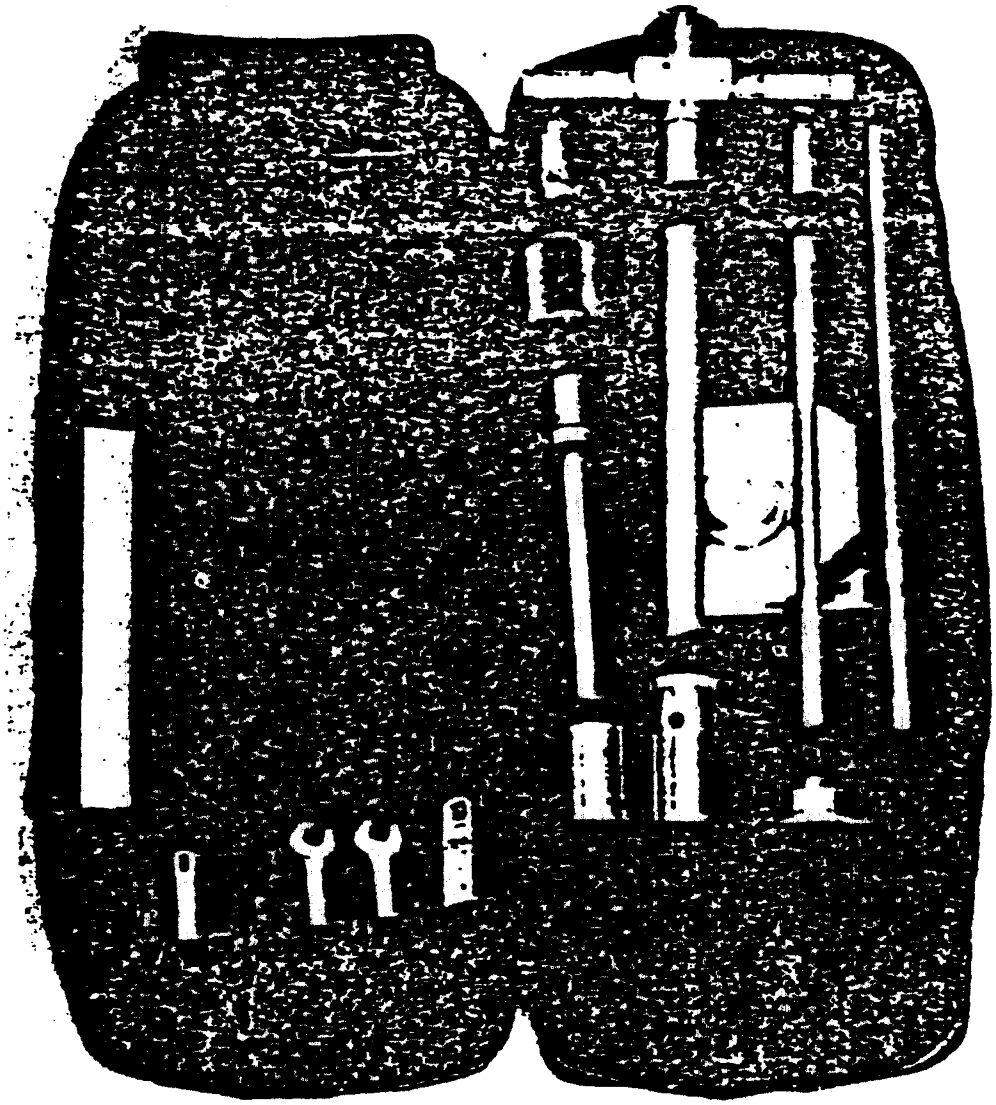

Figure 1. Test Set, Soil Trafficability

c. Operation.

(1) Place the hands over each other on the handle, palms down, and approximately at right angles, to minimize eccentric loading of the proving ring and to help keep the staff vertical.

(2) Apply force until slow, steady downward movement occurs.

(3) Take a dial reading just as the base of the cone is flush with the ground surface. To do this, watch cone descend until an instant before the cone base is expected to be flush with the ground surface, then immediately shift the vision to the dial face. Contiune the slow, steady downward movement and take successive dial readings at appropriate intervals, usually at 6-inch intervals, to a depth of 18 inches. If it is necessary to stop the downward progression of the cone penetrometer for any reason, the progress may be resumed with no adverse effects on cone penetrometer readings. For example, when only one man is on the trafficability test, he may find it convenient to make two cone penetrometer readings, stop the penetration to record the readings, resume the penetration to obtain two additional readings, stop and record, and so on.

Note. The use of an assistant to the operator increases the speed with which measurements can be made and recorded and usually diminishes the likelihood of errors. Some two-man teams prefer that the assistant merely record the values the operator verbally transmits, while other teams prefer that the assistant announce the proper depth to the operator as well as record the reading.

d. Cautions.

(1) Keep the instrument vertical.

(2) Do not attempt to make readings that are higher than the capacity of the dial, since this might overstress the proving ring.

(3) If dial capacity is exceeded at less than 18 inches of penetration, make another penetration nearby because the cone might be striking an isolated rock fragment or other hard, small object.

(4) Do not withdraw the instrument by the ring, but always by the staff or the handle.

(5) Be very careful to read the cone index at the proper depth. If readings are actually made as little as 1/4 inch from the proper depth and recorded as being at the proper depth, an average of such readings will not accurately reflect the average strength at that depth. Carelessness in making proper depth determination is probably the greatest source of error in the use of the penetrometer.

Training Penetrometer Operators

Operators should be trained in an area of uniform soil conditions. The instructor should take approximately 50 sets of readings spaced equally over the area. The average cone indexes for 6-inch layers should be computed and used as standards or references. The trainee should be instructed in all proper techniques of operation and should practice penetration under the eye of a qualified instructor until he has become familiar with the techniques of operation. He then should make about 50 sets of readings, using an assistant to record them. The average cone indexes obtained by a trainee should then be compared to the standard. If the trainee's readings deviate widely, the causes for the deviation should be sought and corrected. In a uniform area, 5 percent deviation is considered wide. The most probable cause of error is carelessness in determining the proper depth.

The rate of progression recommended is such that four readings (surface, 6-, 12-, and 18-inch) can be measured in 15 seconds in a continuous penetration in a soft soil. Much slower or faster rates of penetration will reflect lower or higher values, respectively, but the discrepancies will not be large. Effects on cone index of variation in rate of penetration for the same operator, or even between experienced operators, are insignificant. The possibility of mechanical imperfections of the cone penetrometer should be investigated if deviations are persistent. Sometimes a needle sticks on a loose dial face or slips on its shaft. Sometimes dial faces are jarred or otherwise rotated around the shaft of the dial, causing an improper zero setting. A damaged or overstressed ring might even require recalibration. A micrometer dial stem may not have been in good contact with the proving-ring bearing block when the instrument was zeroed.

Care and Adjustment of the Penetrometer

a. General Care. Little care is required beyond keeping the penetrometer free from dirt and rust, keeping all parts tight, and frequently checking and, if necessary, rezeroing the instrument. Particular care should also be taken to see that no grit is caught between the stem of the dial and the lower mounting block.

b. Dial. The micrometer dial is a sensitive instrument that should be protected against water and rough usage. It should never be immersed in water and should be wiped dry as soon as possible after its use in rainy weather. When transported by truck, the dial should be cushioned by wrapping it in paper or cloth.

c. Bearing-Block Adjustments. If either or both bearing blocks should become loosened and moved, they should be adjusted so that they lie on the same diameter of the ring and retightened, and the proving ring recalibrated. Calibration while on reconnaissance is not feasible. All readings made in the field after bearing blocks have had to be removed should be noted and corrected according to the calibration made later.

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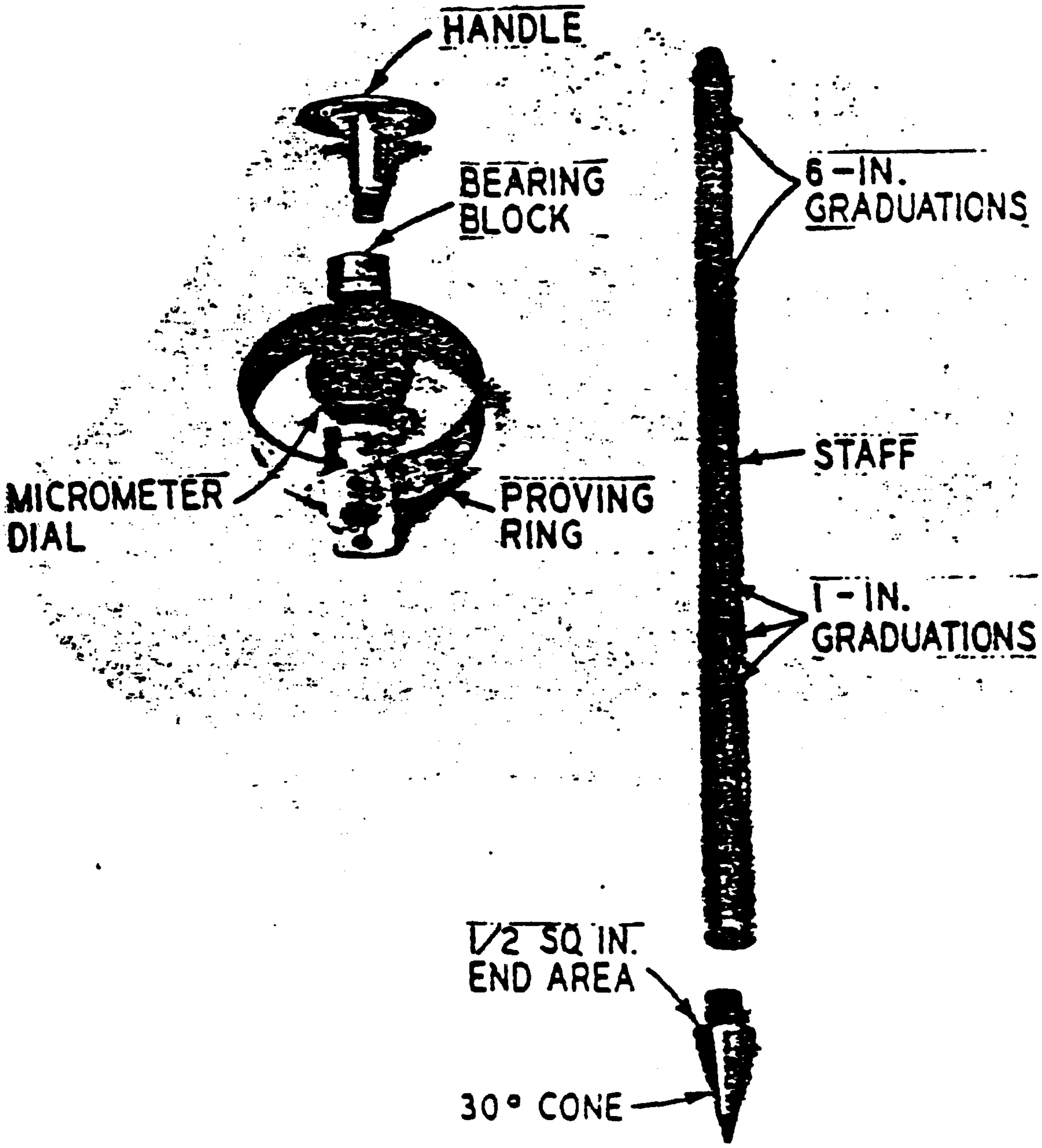

Figure 2. Cone Penetrometer

d. Cone Replacement. Considerable use of the same cone may result in a rounding of its point. This will not affect the accuracy of the instrument; but if the base of the cone has had excessive wear or is deformed by hard usage, the cone should be replaced.

e. Proving-Ring Recalibration. The calibration will remain true for the life of the instrument unless the bearing blocks are actually moved or the ring is severely overstressed, deformed by a hard knock, or subjected to extreme changes in temperature or other unusual strains. If the ring needs recalibration, the following steps should be taken:

(1) Remove handle and staff.

(2) Place lower mounting block of the ring assembly on a smooth, horizontal surface.

(3) Check bearing-block alinement and tightness. Both blocks should be on the same diameter of the ring. A drafting triangle or a carpenter's square may be used in this operation. The bolts should be snug.

(4) The stem of the dial should bear firmly on the lower block, with sufficient travel of the arm available for the full range (approximately 1/10-inch deflection) of the proving ring. The dial can be moved up or down by adjusting the two nuts on the threaded stud that holds the gage in position. Both nuts should be tight when in final position.

(5) Zero the dial by rotating its face so that "0" is under the needle (paragraph 9-7b).

(6) Add load in 10-pound increments up to 150 pounds, marking or noting the position of the needle on the dial after the addition of each load increment. Any of the following loading methods may be used:

(a) Deadweights may be added to the top of the ring assembly. If a plate is used to hold the weights, its weight should be considered in the first 10-pound load.

(b) Any of the load machines commonly used in laboratory work may be used to apply the load.

(c) The ring assembly may be placed on a set of platform scales and the load increments applied by a jack and measured with the platform scales.

(7) Remove load in 10-pound increments, noting the position of the needle after the removal of each increment.

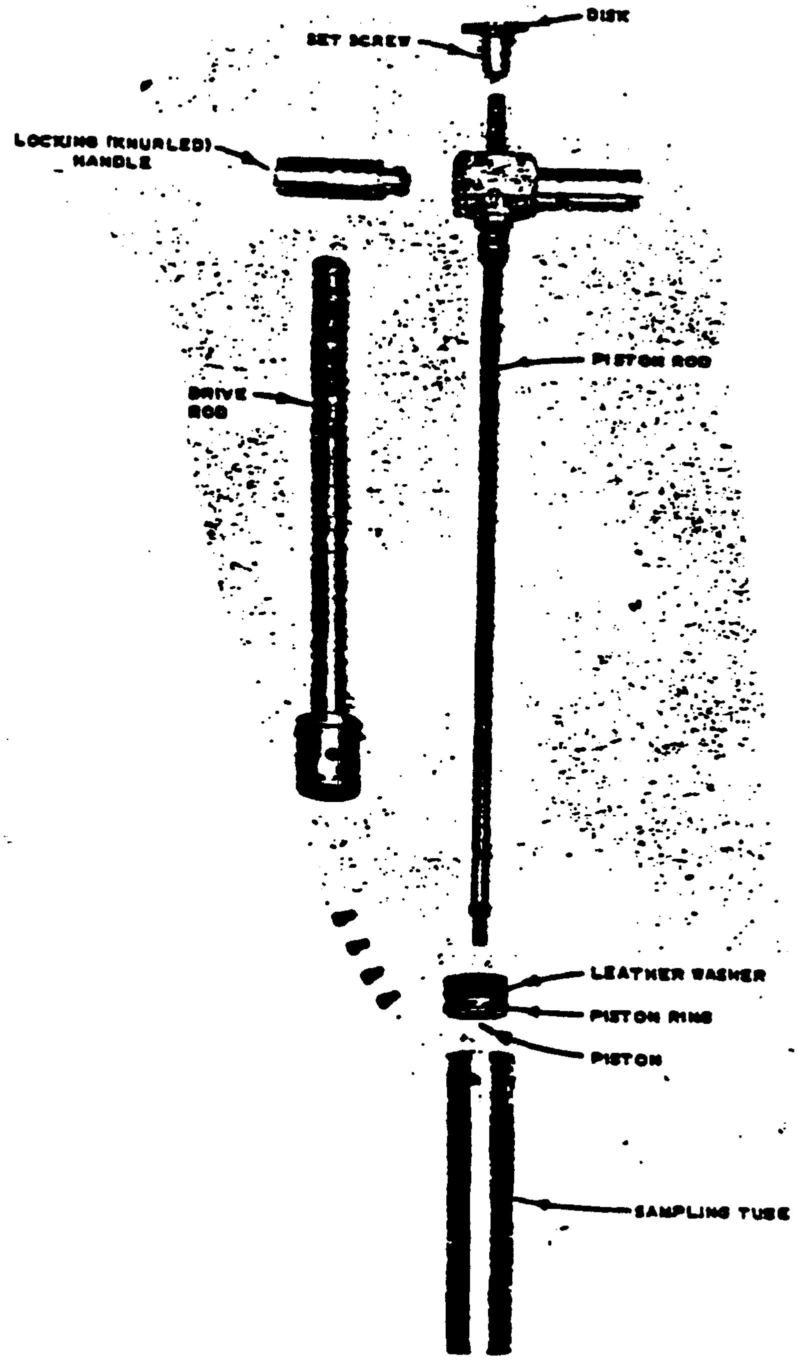

Figure 3. Soil Sampler

(8) The load run should be made at least twice, using the average of the needle position for each increment as the final point.

(9) Some variation in needle position will occur but will not be significant.

(10) When 10-pound intervals have been established on the face of the dial, they may be marked 20, 40, etc., to 300. Each interval may then be subdivided into four subintervals. Each interval should be subdivided separately, since the arcs for various 10-pound intervals are not necessarily the same.

Soil Sampler

A piston-type soil sampler is used to extract soil samples for remolding tests.

a. Use. Hold the disk at the top of the piston rod firmly with one hand to prevent vertical movement of the piston, and force the sampling tube into the soil with the other hand. In firm soils, two men often are needed to force the sampler into the soil. After locking the piston rod by turning the knurled handle, twist the instrument slightly and withdraw. Deposit the sample directly into the remolding cylinder.

b. Care. It is essential to keep the inside of the sampling tube, the piston ring, and the leather washer reasonably clean. After five to twenty-five samplings, depending upon the type of soil, immerse the tube first in water and then in fuel oil, working the piston up and down five or six times in each liquid. Wipe off the excess fuel oil, then squirt light machine oil into the tube. If the instrument becomes stiff and hard to work, remove the tube, disassemble, and thoroughly clean the piston and oil the leather washer. Tube walls and cutting edges are comparatively soft and should be handled with some care.

c. Adjustment. The effective piston rod length should be adjusted to keep the face of the piston flush with the cutting edge of the tube when the piston rod handle (disk) is fully depressed. This is done by loosening the setscrew on the handle, screwing the handle up or down to the correct position, and retightening the setscrew.

Remolding Test

a. Equipment. The equipment for the remolding test consists of a steel cylinder approximately 2 inches in diameter and 8 inches long, mounted on an aluminum base, 2-1/2-pound steel drophammer sliding on an 18-inch steel staff with handle, and a cone penetrometer. The cone penetrometer may be equipped

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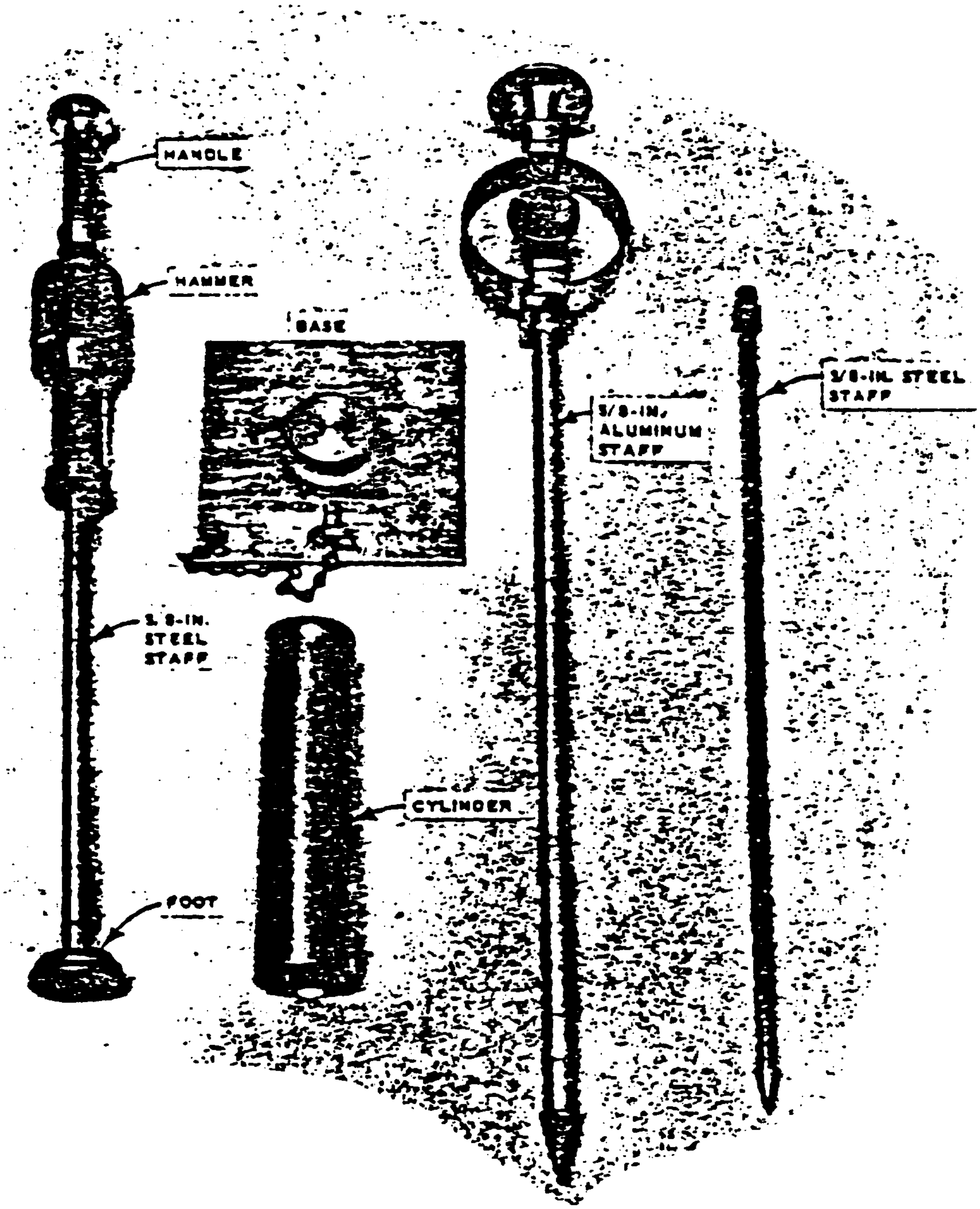

Figure 4. Remolding Test Equipment

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with either the aluminum shaft with the 0.5-square-inch cone (for fine-grained soils) or more slender steel shaft with the 0.2-square-inch cone (for remoldable sands). The penetrometer is used to measure soil strength in the cylinder before and after remolding. The sampler is used to obtain the soil sample and place it in the remolding cylinder.

b. Test Procedure for Fine-grained Soils. Take a sample with the sampler, eject it directly into the remolding cylinder, and push it to the bottom of the cylinder with the foot of the drophammer staff. Measure the strength with the penetrometer (aluminum staff) by taking cone index readings as the base of the cone enters the surface of the soil sample and at each successive inch to a depth of 4 inches. Next, apply 100 blows with the drophammer falling 12 inches, and measure the remolded strength from the surface to the 4-inch depth at 1-inch increments, as was done before remolding. Occasionally, a sample is so hard that it cannot be penetrated the full 4 inches. In such cases, the full capacity of the dial (300) is recorded to each inch below the last reading obtained. Fhe sum of the five cone index readings after remolding divided by the sum of the five cone index readings before remolding gives the remolding index.

c. Test Procedure for Remoldable Sands. The procedure is generally the same as that for fine-grained soils, except that the cone index measurements are made with the slender staff and small cone and the sample is remolded by placing a rubber stopper in the top of the tube and dropping it (along with cylinder and base) 25 times from a height of 6 inches onto a firm surface, such as a piece of timber.

APPENDIX 5

ADDITIONAL INFORMATION

1. This criteria was developed from soil trafficability research conducted at the U.S. Army Corps of Engineers Waterways Experiment Station (WES), Mobility Systems Division.

2. The Corps of Engineers Soil Trafficability Set can be purchased at the following location (Please contact AGK-620 if the equipment is available at other locations so this list can be updated):

Longyear U.S. Products Group
79 Algena Court
St. Peters, MO 63376
1-800-221-4440
Cat. #CN974

3. If an airport sponsor is interested in having soil trafficability maps developed for his airport, this service can be provided by WES on an actual cost basis. For further information please contact:

Richard Gillespie, P.E.
Branch Chief
U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
P.O. Box 631
Vicksburg, Mississippi 39180-6199
1-601-634-2454
Fax: 1-601-634-3087

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Appendix 6: Changes from PPM 5210.1

1. Appendix 5 has been updated with the current name of a Soil Trafficability Set supplier and the current contact person at the U.S. Army Corps of Engineers.

2. Terminology throughout document has been changed from Crash/Fire/Rescue (CFR) to Airport Rescue and Fire Fighting (ARFF).